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TITLE

METHOD FOR ESTIMATING REPAIR ACCURACY OF A MASK SHOP

5   ## BACKGROUND OF THE INVENTION

Field of the Invention:
The present invention relates to a method for
estimating repair accuracy of a mask shop, which provides a
10   basis for engineers to determine a qualified mask shop.

Description of the Prior Art:
Masks are frequently used in a semiconductor
manufacturing process. A typical mask comprises a
15   transparent substrate such as a quartz substrate and a
light-shielding or absorbing layer such as a chrome layer
with a thickness of 1000Å on the substrate. A phase-shift
mask further comprises a layer generating a phase shift for
the light penetrating therethrough.
20   A typical mask manufacturing process comprises the
steps of depositing a chrome layer on a quartz substrate,
depositing a photoresist layer on the chrome layer,
patterning the chrome layer by etching under the masking of
the photoresist layer processed by e-beam writing and
25   developing.
Defects on the chrome layer are usually generated after
the previously described steps. They include clear defects
which are missing parts of the chrome layer and opaque
defects which are redundant parts of the chrome layer. A

further step of chrome depositing is needed to repair the clear defects. As for repair of the opaque defects, a step of chrome sputtering using FIB (Focus Ion Beam) is implemented.

5　　　As shown in FIG.1, the step of chrome depositing is implemented for repairing a clear defect on a line 121 of a chrome layer 12 on a quartz substrate 11. A gentle slope of chrome, rather than a sharp wall, is formed where the clear defect is repaired and some chrome particles are scattered

10　on the quartz substrate 11 in the vicinity of the area where the defect is repaired. Thus, a contaminated area 111 which deteriorates the transparency of the quartz substrate 11 is formed.

　　　The repair accuracy of the mask shop is very important

15　due to the shrinkage of ICs and since defects of the chrome layer always exist. Engineers are eagerly to have a estimation basis of the repair accuracy to determine a qualified mask shop.

20　　　　　　　　　　　**SUMMARY OF THE INVENTION**

　　　Therefore, the object of the present invention is to provide an estimating method for the repair accuracy for the engineers to determine a qualified mask shop.

　　　The present invention provides a method for estimating

25　repair accuracy of a mask shop. The method comprises the steps of providing a mask having a light-shielding layer with a pattern of a plurality of lines, each of which has a defect, using the mask shop to repair the defects, whereby contaminated areas are formed in the vicinity of areas where

the defects are repaired, measuring first light intensities
of the contaminated areas, and second and third light
intensities of two sides of the contaminated areas, and
calculating ratios of means of the second and third light

5 intensities to the first light intensities for estimating
the repair accuracy.

Therefore, by using the mask shop to repair the defects
on the vertical and horizontal line with different widths,
and statistically calculating the errors of the results, the

10 repair accuracy of the mask shop is determined.

BRIEF DESCRIPTION OF THE DRAWINGS

The following detailed description, given by way of
example and not intended to limit the invention solely to

15 the embodiments described herein, will best be understood in
conjunction with the accompanying drawings, in which:

FIG.1 is a diagram showing a cross section of a mask
having a clear defect reoaired.

FIG. 2A and 2B are diagrams showing a pattern of

20 vertical lines on a chrome layer according to one embodiment
of the invention.

FIG. 3A and 3B are diagrams showing a pattern of
horizontal lines on a chrome layer according to one
embodiment of the invention.

25 FIG. 4A and 4B are diagrams showing a pattern of lines
having defects with different areas on a chrome layer
according to one embodiment of the invention.

FIG. 5 is a flow chart of a method for estimating repair accuracy of a mask shop according to one embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 2A is a diagram showing a pattern of vertical lines on a chrome layer of a mask according to a first embodiment of the invention.

The mask comprises a transparent quartz substrate 21 and a chrome layer 22. The chrome layer 22 has a pattern of lines comprising vertical lines 221 with defects 222 which are indentations of the lines 221. The widths of the vertical lines 221 are represented by "a" and the widths of the indented defects 222 along the direction vertical to the lines 221 are 0.5a. The widths a range from 0.5μm to 2μm. In this embodiment, the widths a are 0.6, 0.9 and 1.2μm.

As shown in FIG.2B, the defects 222 are filled using a mask shop to be estimated by chrome depositing, whereby contaminated areas 211 are formed on the substrate 21 in the vicinity of areas where the defects 222 are repaired. The light intensities $Intensity_1$ of the contaminated areas 211, and the light intensities $Intensity_2$ and $Intensity_3$ of two sides of the contaminated areas 211 are measured. Ratios $Intensity_{bias}$ for each lines 221 are calculated according to the following equation.

$$Intensity_{bias} = \frac{Intensity_1 - (Intensity_2 + Intensity_3)/2}{(Intensity_2 + Intensity_3)/2}$$

Therefore, the four ratios $Intensity_{bias}$ are obtained for each group of the lines 221 with width of 0.6, 0.9 and

1.2 μm. A mean and 3δ value of the ratios Intensity$_{bias}$ are also obtained for each group. Accordingly, the repair accuracy of the mask shop is estimated. The number of the lines 221 is only for example and is usually more than 4 for

5   a statistically effective estimation.

FIG. 3A is a diagram showing a pattern of horizontal lines on a chrome layer of a mask according to a second embodiment of the invention. The same elements in FIG.2A, 2B, 3A and 3B refer to the same symbol.

10   The mask comprises a transparent quartz substrate 21 and a chrome layer 22. The chrome layer 22 has a pattern of lines comprising horizontal lines 321 with defects 322 which are indentations of the lines 321. The widths of the horizontal lines 321 are represented by "a" and the widths

15   of the indented defects 322 along the direction vertical to the lines 321 are 0.5a. The widths a range from 0.5 μm to 2 μm. In this embodiment, the widths a are 0.6, 0.9 and 1.2 μ m.

As shown in FIG.3B, the defects 322 are filled using a

20   mask shop to be estimated by chrome depositing, whereby contaminated areas 311 are formed on the substrate 21 in the vicinity of areas where the defects 322 are repaired. The light intensities Intensity$_1$ of the contaminated areas 311, and the light intensities Intensity$_2$ and Intensity$_3$ of two

25   sides of the contaminated areas 311 are measured. Ratios Intensity$_{bias}$ for each lines 321 are calculated according to the following equation.

$$Intensity_{bias} = \frac{Intensity_1 - (Intensity_2 + Intensity_3)/2}{(Intensity_2 + Intensity_3)/2}$$

Therefore, the four ratios $Intensity_{bias}$ are obtained for each group of the lines 321 with width of 0.6, 0.9 and 1.2 μm. A mean and 3δ value of the ratios $Intensity_{bias}$ are also obtained for each group. Accordingly, the repair

5 accuracy of the mask shop is estimated. The number of the lines 321 is only for example and is usually more than 4 for a statistically effective estimation.

 FIG. 4A is a diagram showing a pattern of lines with different areas on a chrome layer of a mask according to a

10 third embodiment of the invention. The same elements in FIG.2A, 2B, 4A and 4B refer to the same symbol.

 The mask comprises a transparent quartz substrate 21 and a chrome layer 22. The chrome layer 22 has a pattern of lines comprising horizontal lines 421 with defects 422 which

15 are indentations of the lines 421. The widths of the horizontal lines 421 are represented by "a" and the widths of the indented defects 422 along the direction vertical to the lines 421 are 0.5a. The widths a range from 0.5 μm to 2 μm. In this embodiment, the widths a are 0.6, 0.9 and 1.2 μ

20 m. Additionally, the widths of the indented defects 422 along the direction parallel to the lines 421 are represented by b. The widths b range from 0.3 μm to 1.5 μm. In this embodiment, the widths b are 0.3, 0.5, 0.7 and 1.0 μ m.

25 As shown in FIG.4B, the defects 422 are filled using a mask shop to be estimated by chrome depositing, whereby contaminated areas 411 are formed on the substrate 21 in the vicinity of areas where the defects 422 are repaired. The light intensities $Intensity_1$ of the contaminated areas 411,

and the light intensities $Intensity_2$ and $Intensity_3$ of two sides of the contaminated areas 411 are measured. Ratios $Intensity_{bias}$ for each lines 421 are calculated according to the following equation.

$$Intensity_{bias} = \frac{Intensity_1 - (Intensity_2 + Intensity_3)/2}{(Intensity_2 + Intensity_3)/2}$$

Therefore, the twelve ratios $Intensity_{bias}$ are obtained for each lines 421 respectively with width a of 0.6, 0.9 and 1.2μm and width b of 0.3, 0.5, 0.7 and 1.0μm. However, the number of the lines 421 with a certain width a and b is usually more than 1 (here for example) for a statistically effective estimation. In this case, a mean and 3δ value of the ratios $Intensity_{bias}$ are also obtained for each group of lines with a certain width a and b. Accordingly, the repair accuracy of the mask shop is estimated.

In the third embodiment, the horizontal lines 421 can be substituted for vertical lines.

FIG. 5 is a flow chart of a method for estimating repair accuracy of a mask shop according to one embodiment of the invention.

In step 51, a mask comprising a chrome layer having a pattern of vertical and horizontal lines with different widths and indented defects with different areas is provided. The number of the lines with a certain width and defect area is large enough for a statistically effective estimation.

In step 52, the defects are filled using a mask shop to be estimated by chrome depositing, whereby contaminated

areas are formed on the substrate in the vicinity of areas where the defects are repaired.

In step 53, the light intensity $Intensity_1$ of the contaminated areas, and the widths $Intensity_2$ and $Intensity_3$

5   of two sides of the contaminated areas are measured. Ratios $Intensity_{bias}$ for each lines are calculated according to the following equation.

$$Intensity_{bias} = \frac{Intensity_1 - (Intensity_2 + Intensity_3)/2}{(Intensity_2 + Intensity_3)/2}$$

Finally, in step 54, means and 3δ values of the ratios

10 $Intensity_{bias}$ for each group of the lines with different widths and defect areas are also obtained. Accordingly, the repair accuracy of the mask shop is estimated.

In conclusion, in the present invention, by using the mask shop to repair the defects on the vertical and

15 horizontal line with different widths and defect areas, and statistically calculating the means and 3δ values of the ratios $Intensity_{bias}$ defined in the invention, the repair accuracy of the mask shop is estimated. This provides a basis for engineers to determine a qualified mask shop.

20 While the invention has been described by way of example and in terms of the preferred embodiment, it is to be understood that the invention is not limited to the disclosed embodiments. On the contrary, it is intended to cover various modifications and similar arrangements as

25 would be apparent to those skilled in the art. Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.